LIGHTNING ARRESTERS

№9061

GENERAL ELECTRIC COMPANY

Lightning Arresters

General Electric Company
Schenectady, N. Y.
Supply Dept.

March 28, 1898

FREQUENT AND UNUSUALLY SEVERE STORMS, ACCOMPANIED BY DESTRUCTIVE LIGHTNING, HAVE RECENTLY RUINED MUCH ELECTRICAL APPARATUS AND RENDERED MANY CIRCUITS INOPERATIVE. THE HEAVY INCREASE IN THE MAINTENANCE ACCOUNT, DUE TO REPAIRS ON APPARATUS DAMAGED BY LIGHTNING AND THE LOSS OF REVENUE WHILE APPARATUS IS DISABLED, ARE GENERALLY REALIZED AND NO ARGUMENT FOR THE POLICY OF COMPLETE EQUIPMENT WITH WELL DESIGNED ARRESTERS IS NECESSARY. ALTHOUGH THE RAPIDITY AND TREMENDOUS POWER OF OCCASIONAL LIGHTNING DISCHARGES PRECLUDES THE POSSIBILITY OF ABSOLUTE PROTECTION, FORTUNATELY SUCH OCCURRENCES ARE EXTREMELY RARE. YEARS OF EXPERIENCE AND THE TESTIMONY OF THOUSANDS OF USERS ASSURE US, HOWEVER, THAT OUR LIGHTNING ARRESTERS INSTALLED ACCORDING TO OUR INSTRUCTIONS, HAVE SAVED PROPERTY TO THE VALUE OF HUNDREDS OF THOUSANDS OF DOLLARS.- - - - - -

A LIGHTNING DISCHARGE.
From a Photograph by Mr. A. H. Binden.

LIGHTNING ARRESTERS

Two important requirements must be fulfilled by a lightning arrester to afford protection to the circuit on which it is installed. The path for the high potential discharge through the arrester must offer less resistance than any other part of the circuit. In other words an effective arrester does not arrest the lightning discharge but provides it a perfectly free path to ground. Careful consideration of the phenomena of high voltage currents is essential in designing lightning arresters, and practical experience must also not be lacking.

Essential Points in Lightning Arrester Design

A second consideration of no less importance arises from the possibility of simultaneous discharges on both sides of a circuit and the fact that even carefully insulated circuits are apt to have leaks to ground in wet weather. While the generator voltage is not sufficient to start an arc across the air gaps of the lightning arrester, it is sufficient to maintain one started by the lightning discharge. An effective lightning arrester must therefore be constructed to prevent the formation of destructive arcs or provide for their immediate extinction.

The Magnetic Blow-out Principle

Some years ago Prof. Elihu Thomson devised a lightning arrester based on the principle that an electric arc may be repelled by a magnetic field. In this device, the air gap across which the lightning discharges to reach the ground, is placed in the field of a strong electro-magnet. When the generator current attempts to follow the high potential discharge it is instantly repelled to a position on the diverging contacts where it cannot be maintained by the generator.

The magnetic blow-out principle has been employed in the construction of a complete line of lightning arresters for all direct current installations and in more than ten years of service magnetic blow-out arresters have always been effective in affording protection to electrical apparatus.

In designing lightning arresters for the protection of high voltage alternating current circuits, however, different conditions have to be met since high voltage arcs are not readily extinguished by a magnetic blow-out. In our recently designed and very successful lightning arrester for alternating current circuits, metallic cylinders with large radiating surfaces are found to so lower the temperature of the arc that volatilization of the metal ceases and the arc is extinguished.

Lightning Arresters for Various Circuits

The variety of our lightning arresters provides for the protection of all forms of electrical apparatus and circuits.

Our Thomson Arc Arrester, Type A, is now found in nearly every arc lighting station. Undoubtedly the success of the arc lighting system has to a great extent been due to the protection provided by this arrester, which was developed simultaneously.

The introduction of low tension incandescent lighting apparatus called for a modification of the Type A Arrester, and the Thomson Incandescent Arrester, Type B, was designed on the same general plan. It has been equally successful in the protection of circuits and machinery. Managers of central stations and isolated lighting plants should see that every feeder and main circuit is provided with a pair of Type B Arresters.

When protection for power generators and electric cars was demanded, further modifications in arresters were necessary and resulted in two types, namely, Type M, Form C, and the more recent Type MD. The Type MD Arrester should be used on all feeders at the station and on all electric cars.

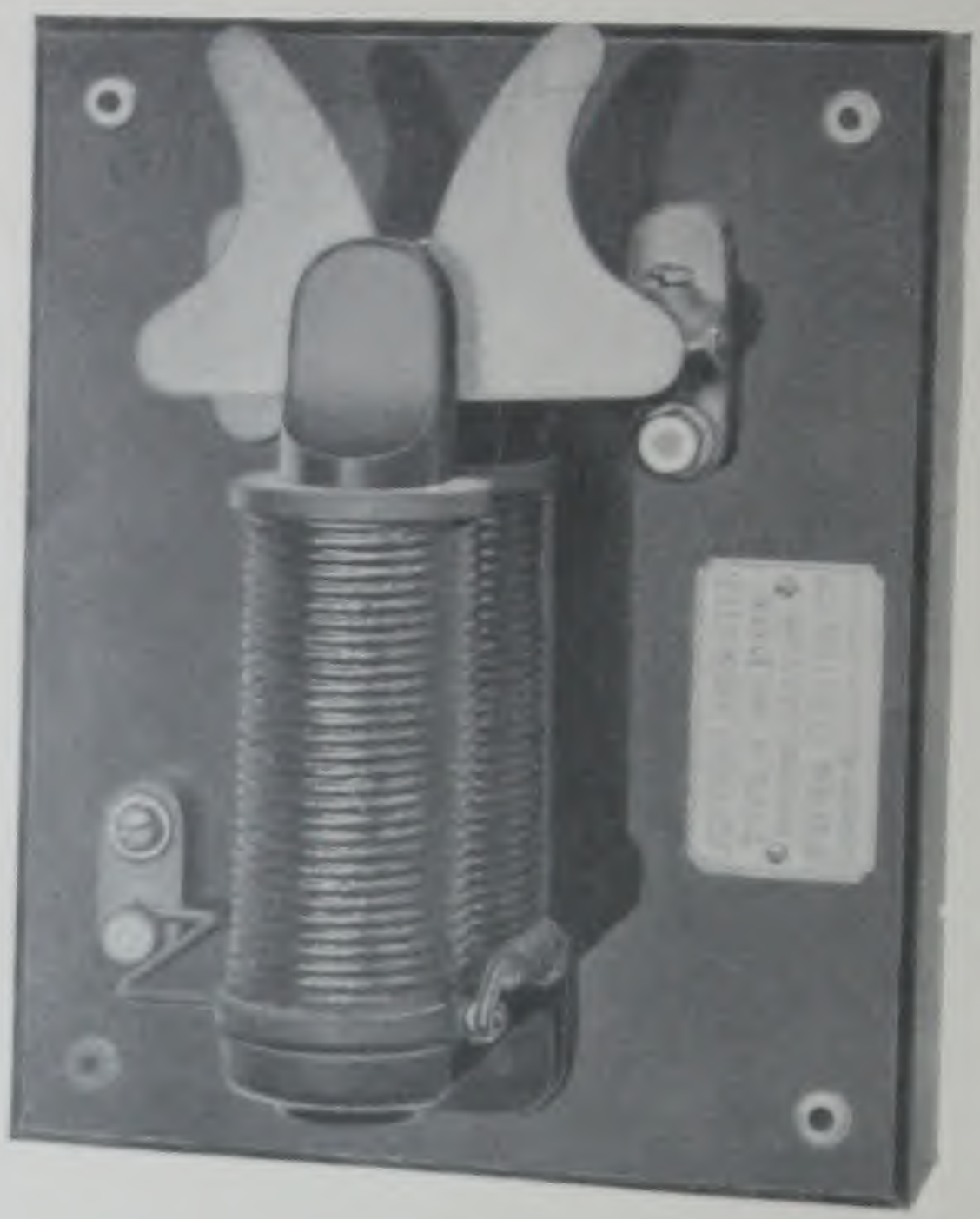
The development of a line of arresters for the protection of alternating current apparatus involved problems requiring superior engineering skill. The GE Arrester has recently been devised and we are already assured by the testimony of many users that this new arrester is completely successful in protecting alternating apparatus.

LIGHTNING ARRESTERS

FOR

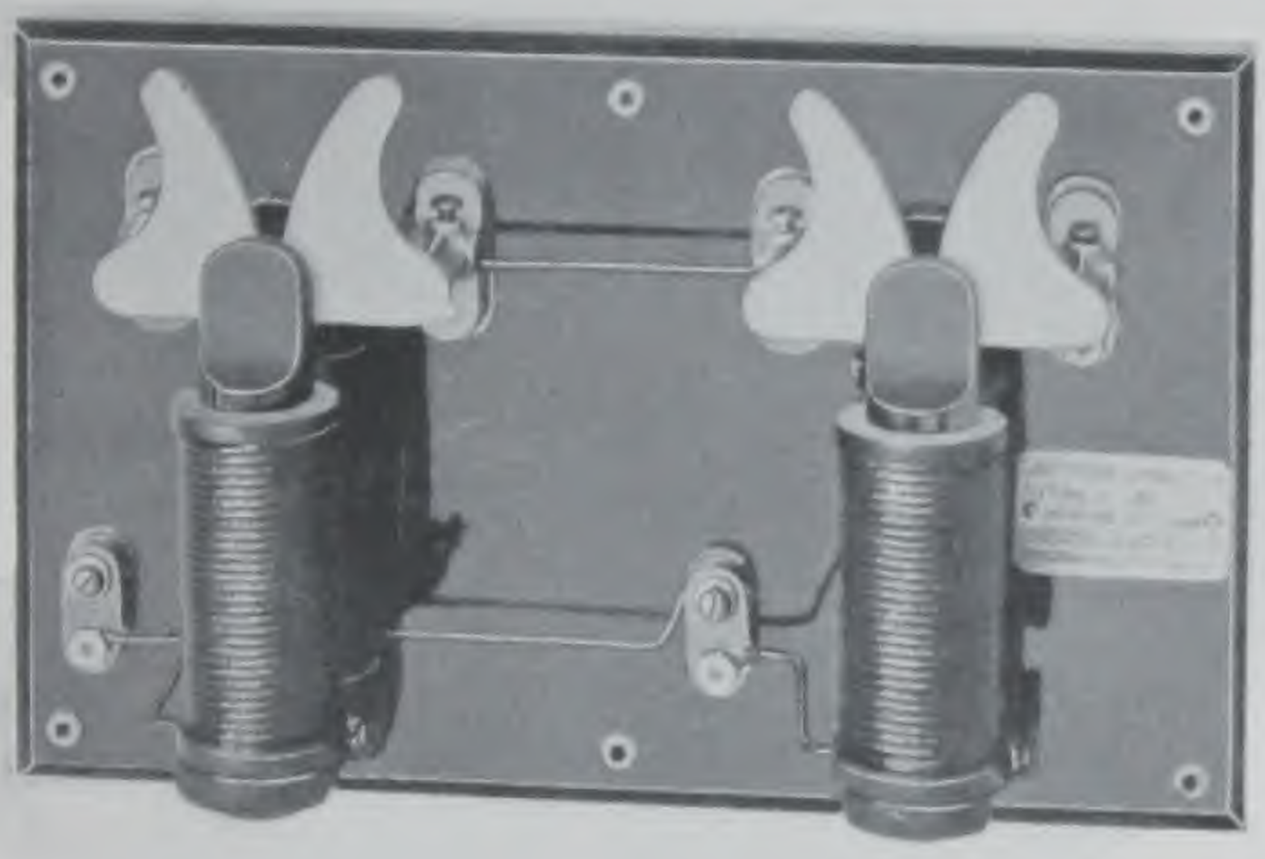
DIRECT CURRENT

CIRCUITS



TYPE A ARC STATION ARRESTER.

THE Type A Arrester is manufactured for the protection of arc lighting circuits, and is in extensive use throughout the world. Its construction includes a pair of diverging terminals mounted on a slate base with an electro-magnet connected in series with the line. The magnet windings are of low resistance and therefore consume an inappreciable amount of energy with the small current used for arc lighting, although they are always in circuit.



TYPE AA ARC STATION ARRESTER.

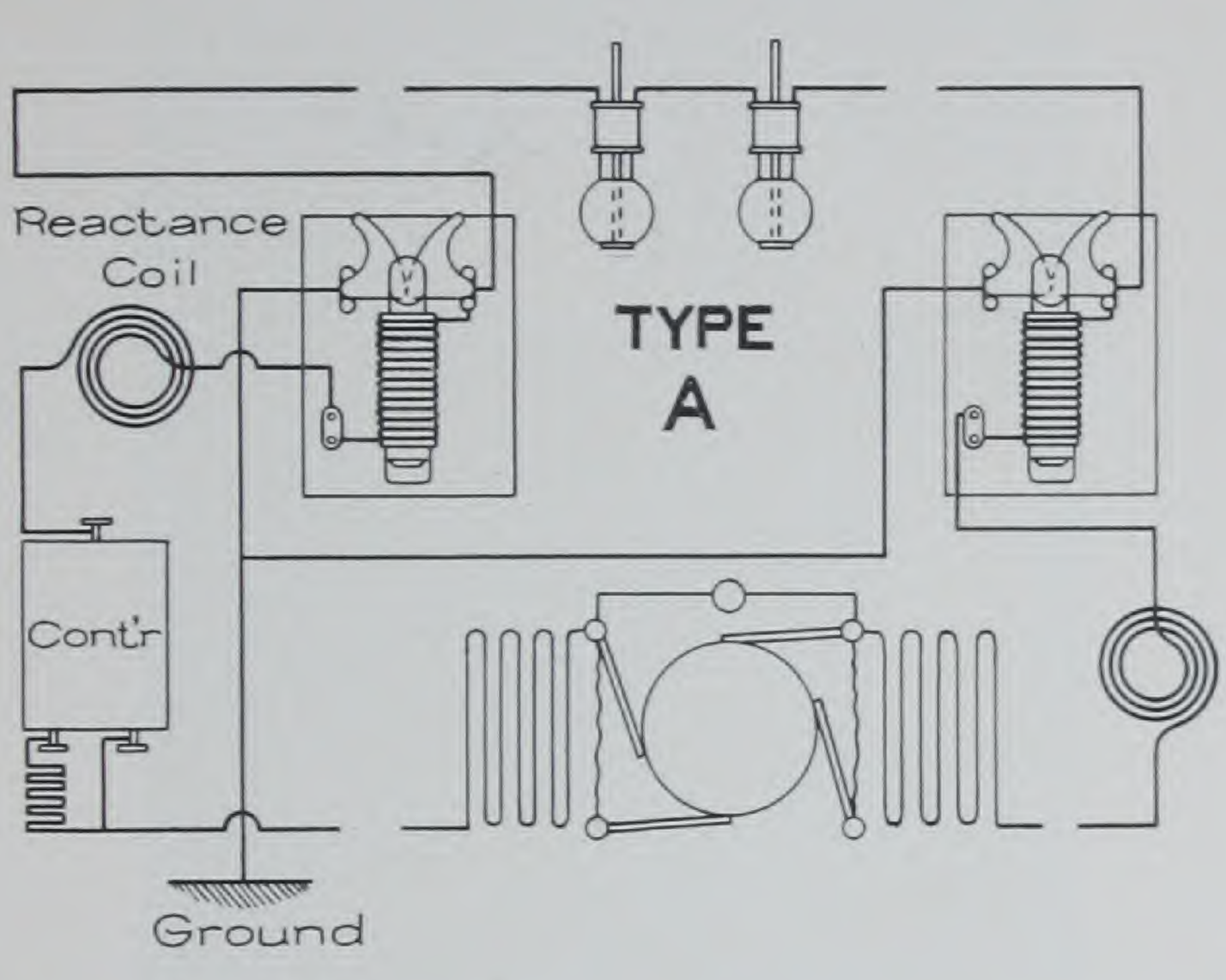
THE single Type A Arrester is suitable for circuits of any number of series arc lamps not exceeding seventy-five. For circuits of higher voltage, a double arrester known as the Type A A is made by mounting two arresters on one base and connecting them in series. One arrester should be installed on each side of the circuit, as shown in the Diagram of Connections.

For use in places exposed to weather, the Type A Arrester is furnished enclosed in an iron case and designated Type A, Form C.

TYPE A, FORM C LIGHTNING ARRESTER.

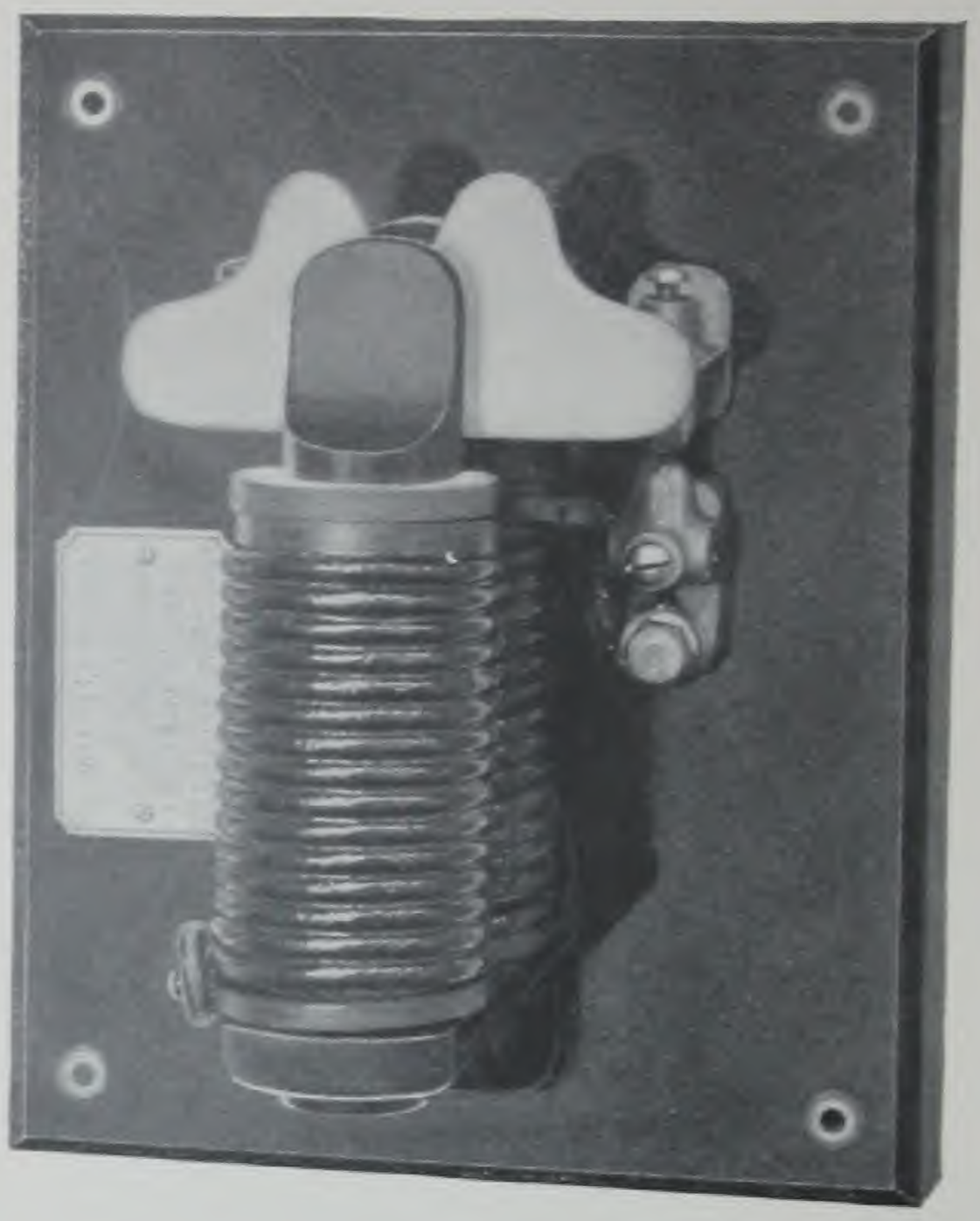
IN IRON BOX FOR LINE USE.

CONNECTIONS FOR TYPE A ARRESTERS.



TYPE A MAGNETIC BLOW-OUT LIGHTNING ARRESTERS.

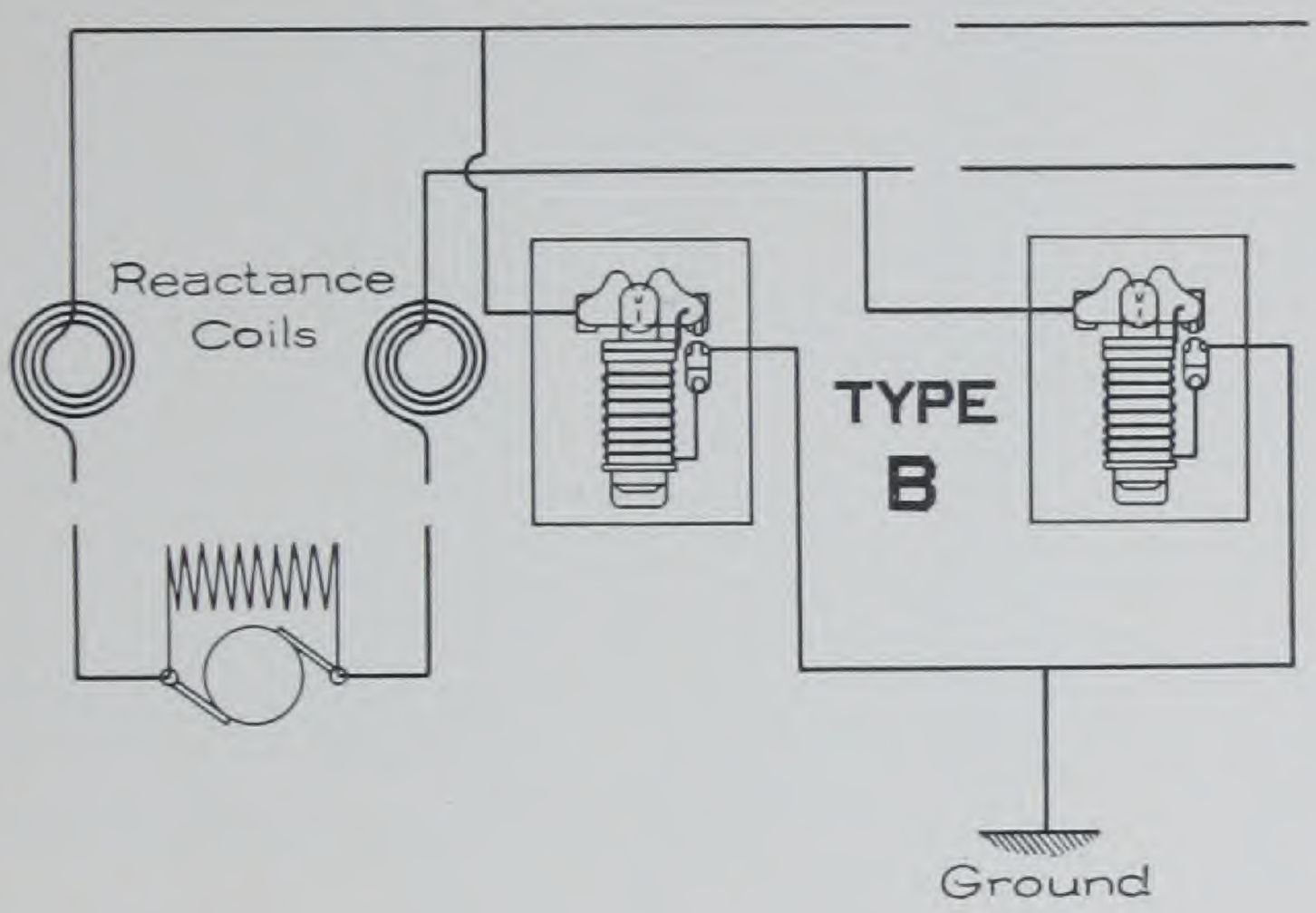
DESCRIPTION.	CAT. NO.
Type A, for station use on arc circuits, 75 lights or less.	2362
Type AA, for station use on arc circuits, over 75 lights.	2081
Type A, Form C, in weatherproof case, for outdoor use.	2368



TYPE B INCANDESCENT STATION ARRESTER.
300 VOLTS OR LESS.

THE construction of the Type B Arrester is similar to that of the Type A, but its magnet windings are excited only when a discharge takes place across the air gap. A supplementary gap is provided in the Type B Arrester, in shunt with the magnets, thus providing a relief for the coils from excessive static charge without affecting their action upon the main gap. The magnet coils, carrying current only momentarily, allow the same arrester to be used on circuits of large and small ampere capacity. The Type B can also be furnished with weatherproof case similar to that used with Type A.

CONNECTIONS FOR TYPE B ARRESTERS.



TYPE B MAGNETIC BLOW-OUT LIGHTNING ARRESTERS.

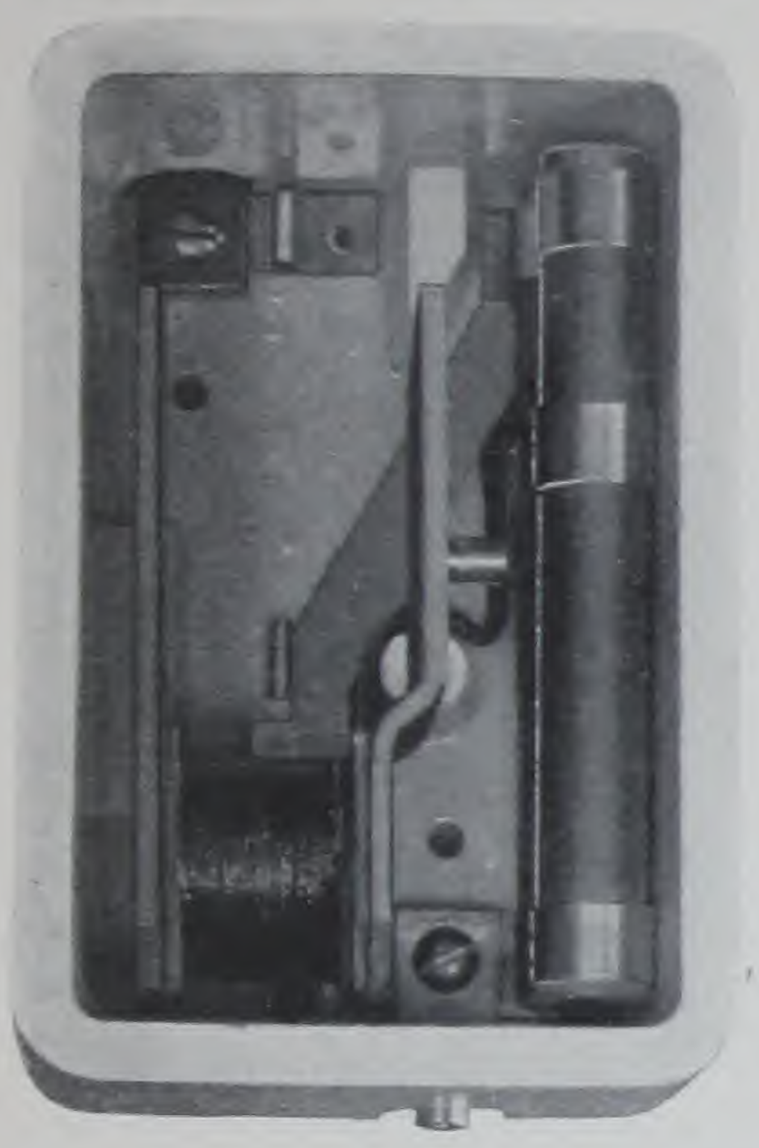
DESCRIPTION.	CAT. NO.
Type B, for station use on direct current constant potential circuits of 300 volts or less . . .	4978
Type B, Form C, in weatherproof case, for outdoor use.	5414

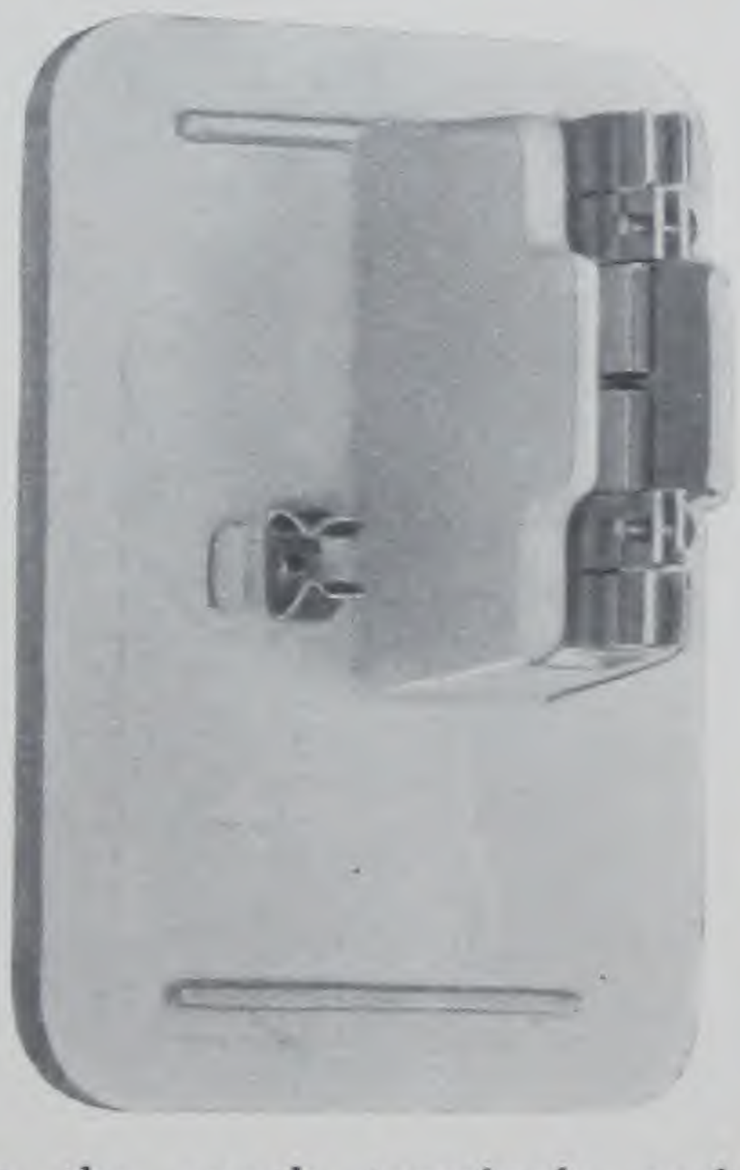
TYPE MD FOR DIRECT CURRENT CIRCUITS
UP TO 850 VOLTS.

THE Type MD Lightning Arrester has been designed for use on direct current circuits up to 850 volts. While similar to our Type M, Form C Arrester, which has been eminently satisfactory, it is considerably smaller and embodies many improvements in construction. It is enclosed in a compact porcelain box measuring 7½″ x 5″ x 4⅛″, and there are no moving parts to get out of order or give trouble. For street car and line use, the arrester is furnished in an additional box of iron or wood as shown on page 19.

This arrester has been adopted as our standard for railway and all direct current 500 volt circuits. It has a short spark gap, a magnetic blow-out, and a non-inductive resistance.

The spark gap of the Type MD Arrester allows a discharge to the ground when the potential rises to 2000 volts. In connection with a reactance coil the short gap affords full protection to the motors and generators under all conditions of high potential discharge. In many cases, cars are provided with lightning arresters, which are not effective below potentials from 8000 to 10000 volts; consequently the high voltage current may ground itself on the motor frame, break down the insulation and cause a burn-out. Railway motors are especially exposed to this danger, as their frames are always connected to ground. While the insulation of our railway motors is required to withstand in test an alternating voltage exceeding 2000 volts, a lightning arrester for railway circuits should provide for grounding potentials considerably lower than that used in the insulation test.





The spark terminals are attached to the lid of the box and are readily inspected or adjusted after removing the lid. They should be examined from time to time and the proper gap of .025″ maintained.

In series with the spark gap is a low non-inductive resistance through which the generator current passes in following the lightning discharge to ground. The resistance limits the current and thus reduces the tendency to burn the spark terminals and increase the spark gap.

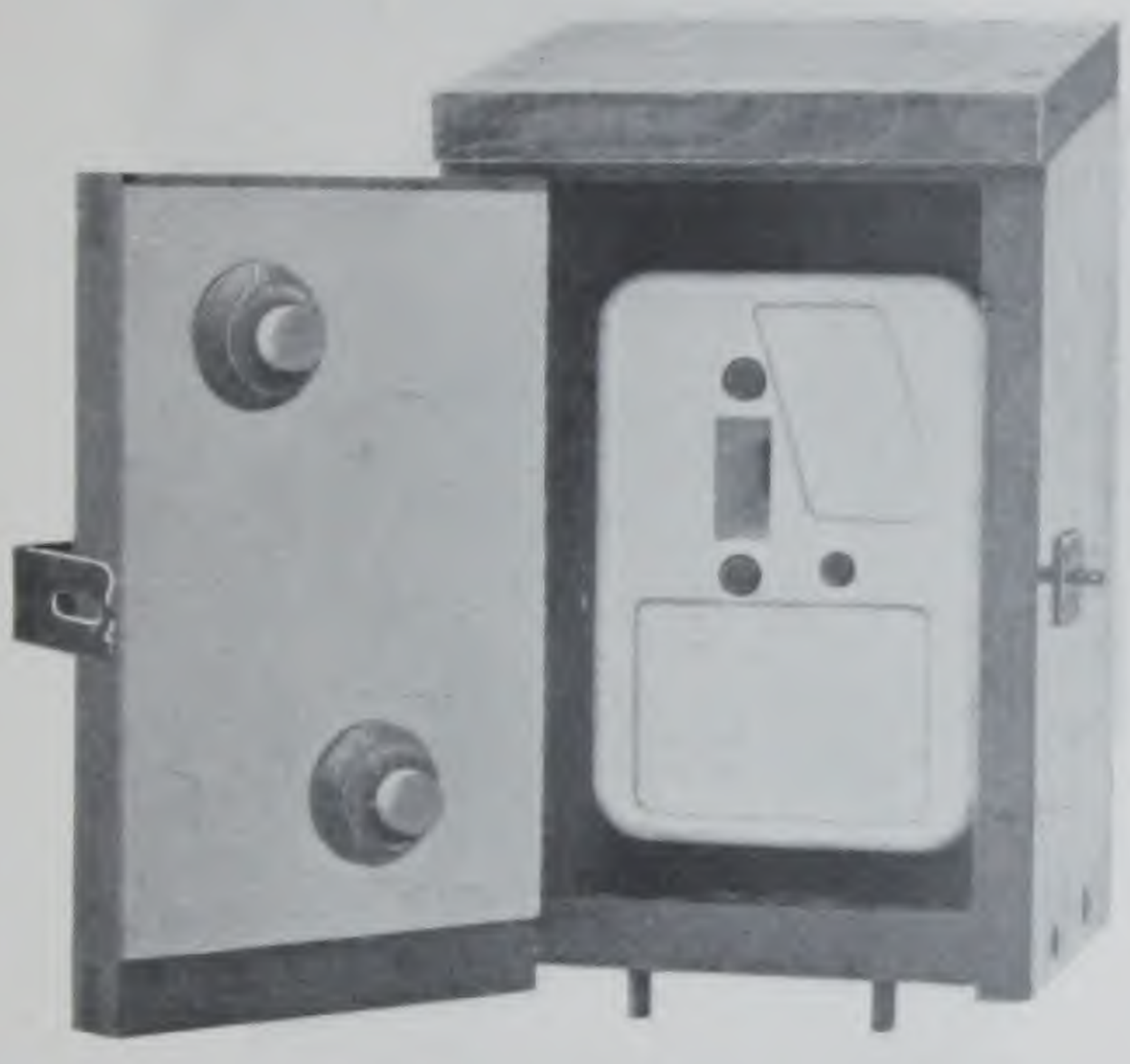
In the Type MD Arrester a blow-out magnet, which is the simplest and most effective automatic device for rupturing an arc, acts instantly to open the ground circuit after the lightning discharge. To eliminate reactance of the magnet winding, it is connected in parallel with a part of the non-inductive resistance.

A reactance coil should be included in the circuit between the arrester and the generator or motor to be protected, as shown in the Diagram on page 20. The reactance of the coil offers a much higher resistance to the lightning discharge than the ground connection and the spark gap of the arrester; the lightning discharge therefore passes to ground through the arrester instead of puncturing the insulation of the generator or motor.

Action of the Reactance Coil

Although the reactance coil (exterior to the arrester) acts to choke a sudden increase of voltage, as in the case of lightning, it does not prevent the gradual building up of a static potential which may cause a discharge as dangerous to insulation as the direct discharge of lightning. On this account the spark gap resistance must be much less than the insulation resistance of the machine to be protected.

MD LIGHTNING ARRESTER IN WOOD BOX.



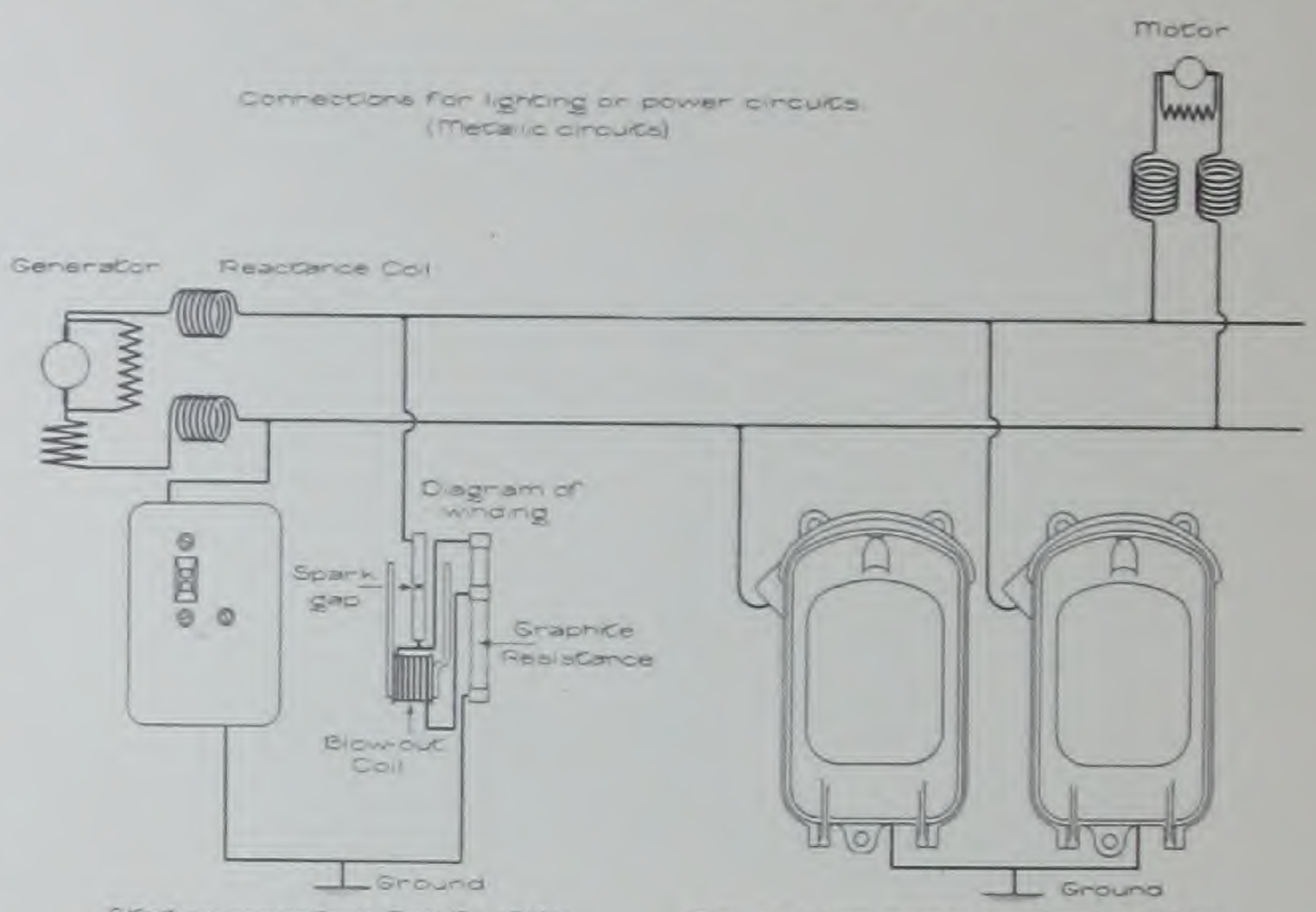
TYPE MD LIGHTNING ARRESTERS.

DESCRIPTION.	CAT. NO.
Type MD Lightning Arrester	12157
Type MD Lightning Arrester in iron box for line use.	12246
Type MD Lightning Arrester in wood box for line use.	12500

CONNECTIONS OF

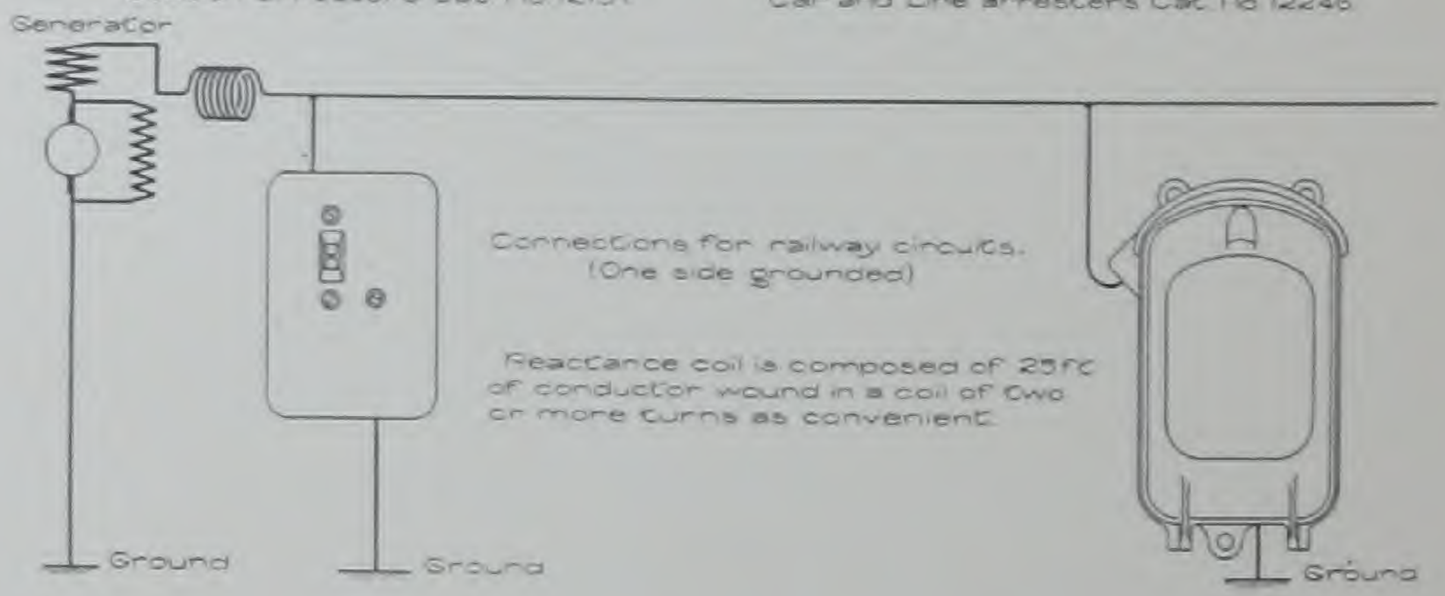
MAGNETIC BLOW-OUT LIGHTNING ARRESTERS TYPE MD

FOR DIRECT CURRENT CIRCUITS UP TO 850 VOLTS



Station arresters Cat. No. 12157

Car and Line arresters Cat. No. 12246

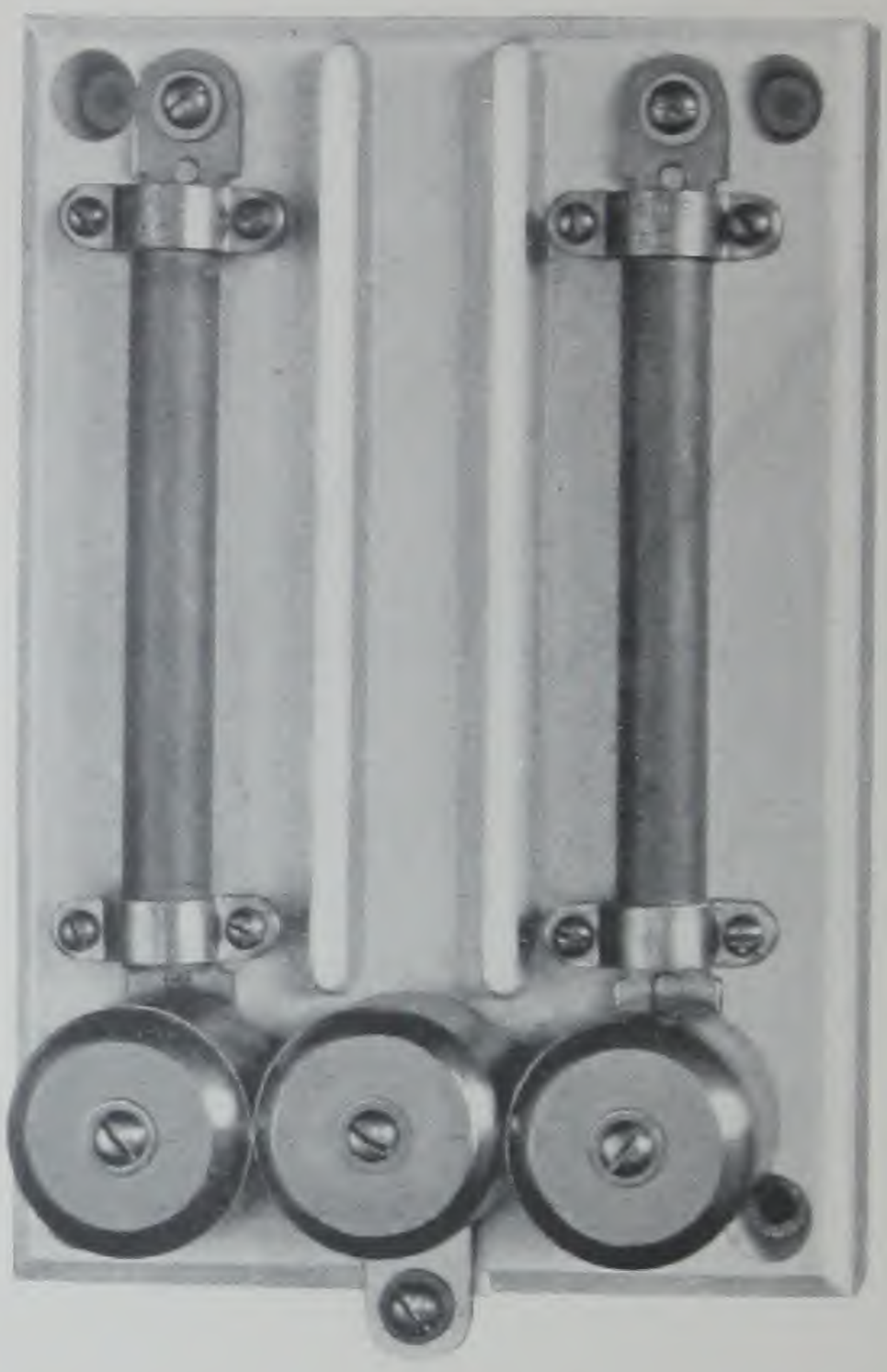


LIGHTNING ARRESTERS

FOR

ALTERNATING CURRENT

CIRCUITS



GE ALTERNATING CURRENT LIGHTNING ARRESTERS.

REPORTS from central station managers show that many lightning arresters designed for alternating current overhead systems are more or less defective. The General Electric Company has met all the requirements of a perfect instrument with the GE Alternating Current Lightning Arresters.

High potential currents are generated in overhead lines by a disturbance of the atmosphere. As both sides of the circuit must be protected with arresters, a simultaneous discharge from each wire causes a short circuit from line to line through the ground connections of the arresters. A slight discharge of atmospheric electricity may cause a flow of current from the alternator sufficient to maintain destructive arcs at the spark gaps of the arresters.

An Important Requirement of a Lightning Arrester

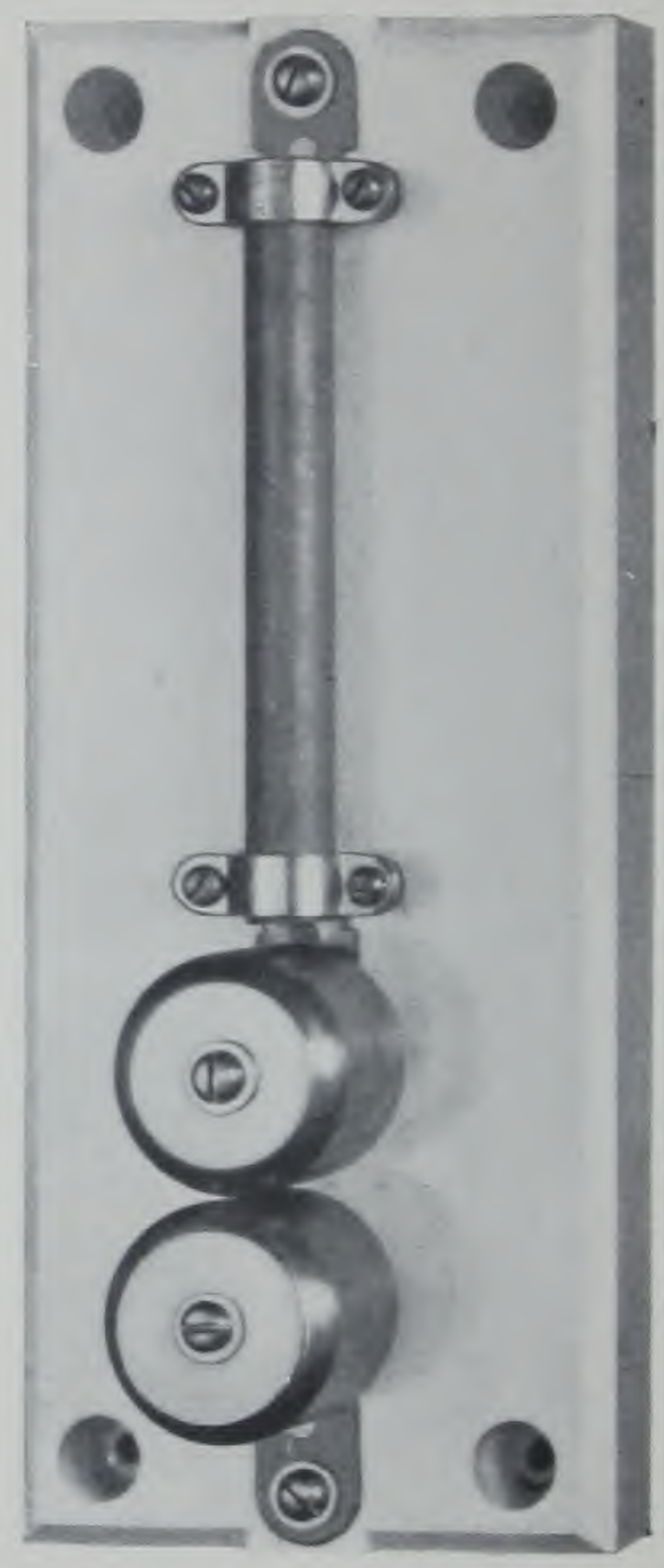
The first requisite, therefore, for an arrester is that it permit the passage of high potential discharges, and at the same time prevent the alternator current from following and maintaining an arc. A simple way to prevent arcing of the alternator current is to make the spark gap in the arrester so long that the alternator cannot maintain an arc. A spark gap several inches in length might be used and would effectively prevent short circuiting of the alternator current. The long gap, however, would not be effective in protecting electrical apparatus from high potential discharges, since ample protection requires that the arresters be the weakest spot of the line: that is, the potential necessary to jump across the spark gaps in the arresters must be less than the potential necessary to puncture the insulation of the electrical apparatus, which the arresters are intended to protect.

A careful record of burn-outs, due to lightning discharges, has disclosed the fact that they generally occur in connection with lines protected by arresters having long spark gaps, or else in electrical apparatus having very poor insulation.

Why Some Lightning Arresters Do Not Protect

Most electrical apparatus designed for operation on 1000 and 2000 volt circuits should not be subjected to a higher potential than 4000 volts between the windings and frame of the machine. In arresters designed for use on these circuits the spark gaps which separate the line from the ground connection should, therefore, be so short that a potential considerably less than 4000 volts will be grounded.

The GE Alternating Current Arresters have been designed to operate properly with very small gap spaces. The arrester for 1000 volt circuits has two metal cylinders 2″ in diameter and



2″ long, separated by a spark gap of about $\frac{1}{32}$″. One cylinder is connected to the overhead line and the other cylinder to the ground and a low non-inductive graphite resistance is placed in circuit. The large radiating surface of the metal cylinders combined with the effect of the non-inductive resistance prevents heating at the time the lightning discharge passes across the gap, and the formation of vapor which enables the current to maintain an arc is thus avoided. The arc is immediately extinguished by the reversal of the alternator current, before an actual short circuit is thoroughly established.

Action of the Alternating Arrester

The action of the arrester is therefore dependent upon the cooling effect of the large metal cylinders aided by the reversal of the alternator current and the introduction of a non-inductive resistance. The arrester under normal action shows a small arc about as large as a pin head between the cylinders.

The arrester for 2000 volt circuits is designed with two gaps of approximately $\frac{1}{32}$″ each and a low non-inductive resistance.

The GE Arresters are now furnished by the General Electric Company for use on all alternating current circuits at practically any potential. For circuits above 2000 volts, the standard 2000 volt double-pole arrester has been adopted as a unit, and several of these are connected in series to give the necessary number of spark gaps.

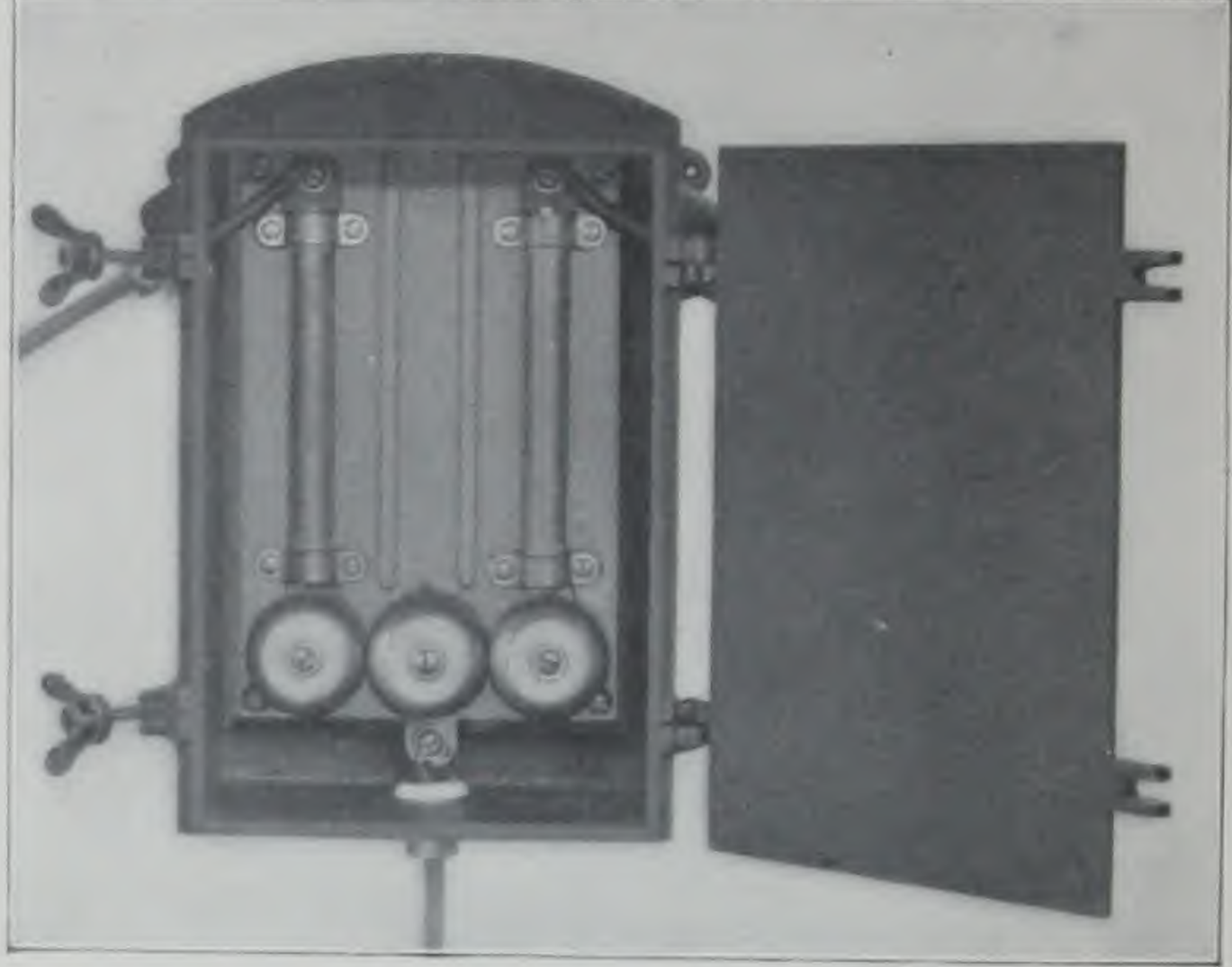
Advantages of a Short Gap Arrester

We recommend that an arrester be installed on each circuit as it enters the station, and in addition that they be freely used on the overhead lines. In many cases we have recommended the installation of arresters within 500 feet of each transformer.

It is better to buy a few effective arresters than a large number of arresters which will not protect the apparatus. Naturally a short gap arrester will protect a longer circuit than one having a longer gap; therefore, a few arresters of our short gap type are more effective than a large number of long gap arresters.

We estimate an annual loss of $300,000 owing to the burning out of electrical apparatus by electrical storms, and think much of this loss can be avoided by the use of short gap arresters.

GE ARRESTER IN IRON BOX FOR LINE USE.



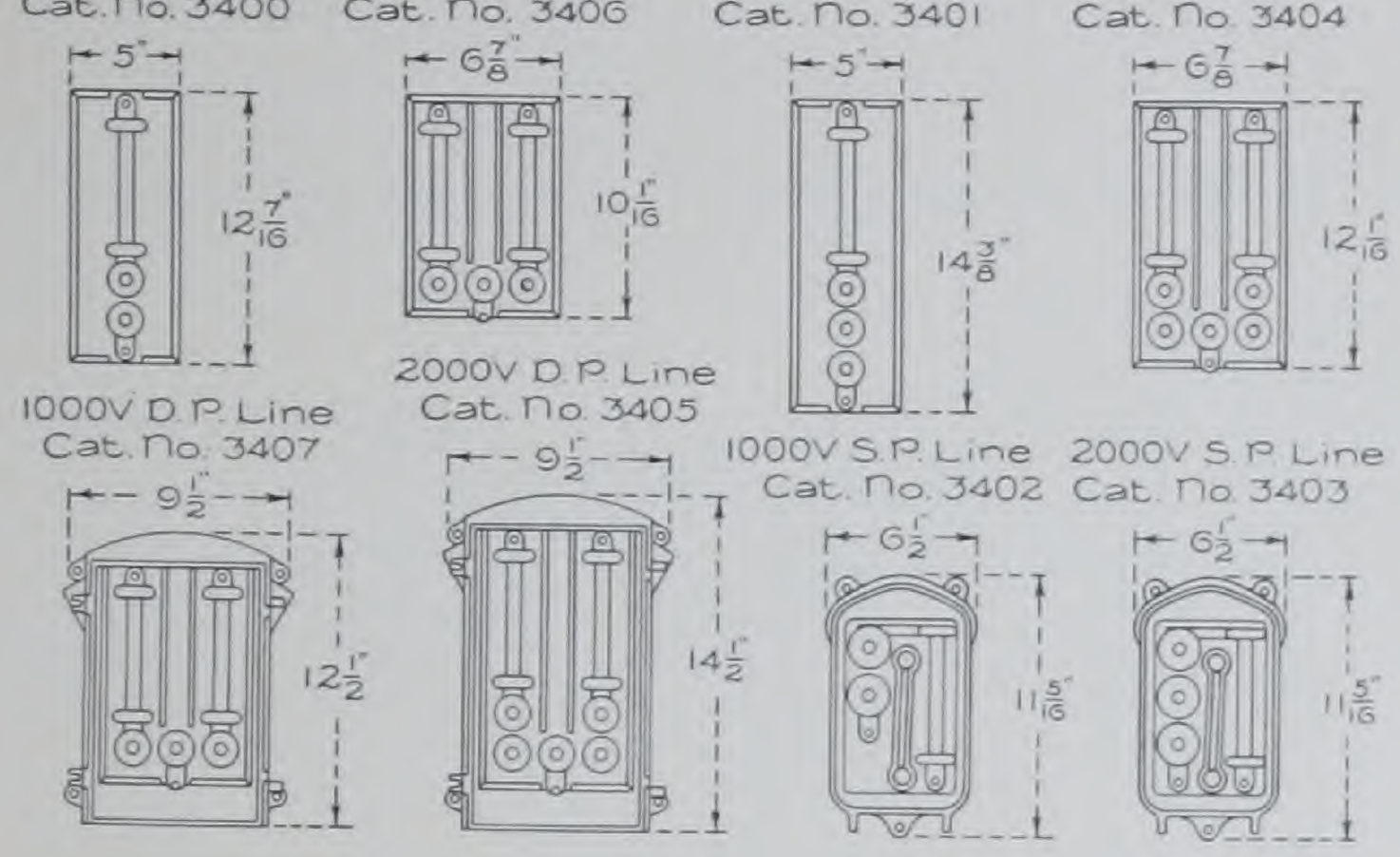
GE ALTERNATING CURRENT ARRESTERS.

DESCRIPTION.	CAT. NO.
1000 Volt Single-pole Station Arrester . . .	3400
2000 Volt Single-pole Station Arrester . . .	3401
1000 Volt Single-pole Line Arrester (in iron box) .	3402
2000 Volt Single-pole Line Arrester (in iron box) .	3403
1000 Volt Double-pole Station Arrester . . .	3406
2000 Volt Double-pole Station Arrester . . .	3404
1000 Volt Double-pole Line Arrester (in iron box) .	3407
2000 Volt Double-pole Line Arrester (in iron box) .	3405

For 3000 volt circuits, use Cat. No. 3404 for Stations and Cat. No. 3405 for Lines, each connected as a Single-pole Arrester, according to the Diagram on page 28.

Information regarding arresters for high voltage circuits furnished upon application.

DIMENSIONS OF
GE ALTERNATING CURRENT LIGHTNING ARRESTERS



INSTALLATION OF THE GE ALTERNATING CURRENT LIGHTNING ARRESTER.

THE GE Alternating Current Lightning Arrester should never be installed on direct current lines, for it will not then extinguish the arc started by a high potential lightning discharge.

The arrester is provided with one gap space of about $\frac{1}{32}''$ for each approximate thousand volts potential. A potential of about 1500 volts is required to jump one gap, and a sufficient number of gaps is provided for each size arrester so that the dynamo potential will not be able to start an arc.

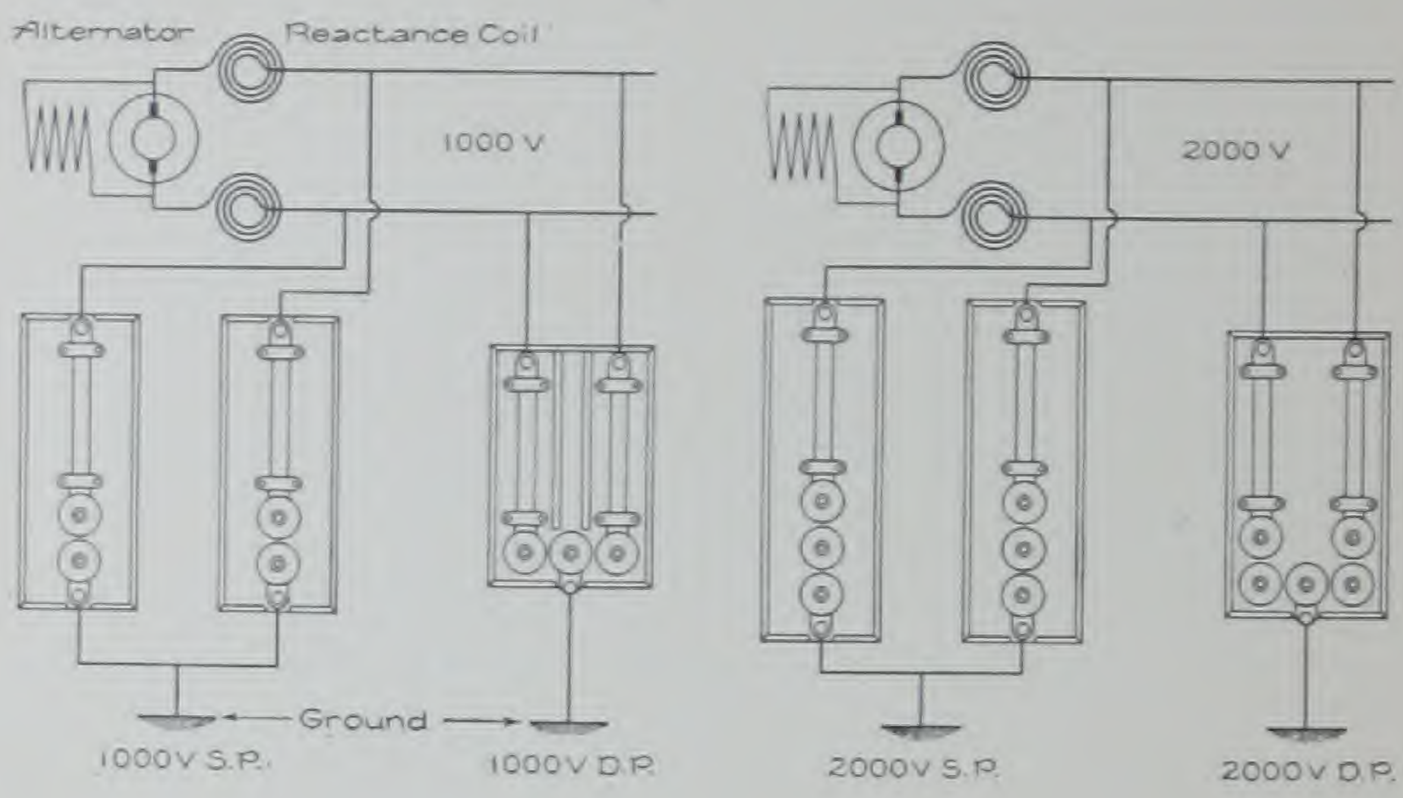
The resistance of the graphite included in circuit to limit the current when the arc is started across the gap by the lightning discharge, is marked on the lower clamp which secures the graphite to the arrester. If the graphite should break, it should be replaced only by graphite having the proper resistance, for if the resistance is too low the arc will not be extinguished.

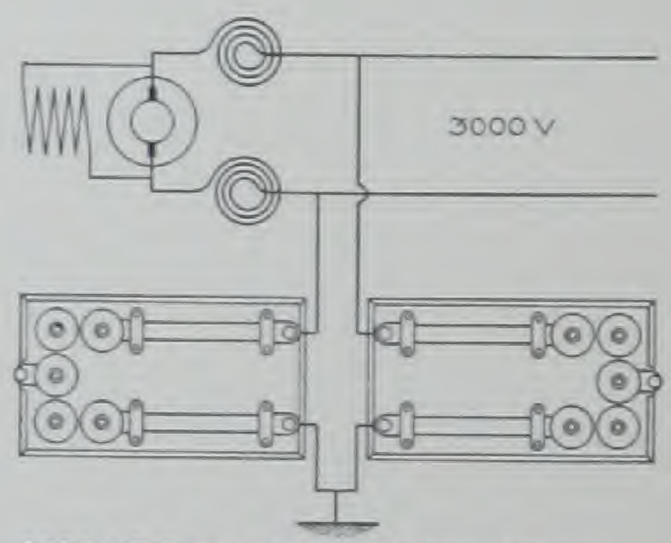
The GE Arrester is an improvement over our former types in that it has fewer gap spaces, and therefore will take the

CONNECTIONS OF

GE ALTERNATING CURRENT LIGHTNING ARRESTERS

1000 TO 3000 VOLTS





2000 V D.P. arresters connected as
3000 V S.P. arresters.

discharges much more readily and so offer greater protection to the apparatus.

The cylinders are so large and heavy that the metal will not be burned away and the gap increased. The air gaps must be kept free from dirt. The connections to ground and line should be made with wire no smaller than No. 4 B. & S.

Arresters should be connected according to the Diagrams on the opposite page.

GENERAL ELECTRIC COMPANY

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